From Dispositions to Possible Worlds

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Abstract

Dispositions (powers, potentialities) have become popular in metaphysics in recent years, and some of their proponents are advertising them as the best metaphysical grounds for modality. This project has a logical as well as an ontological side: dispositionalists offer modal and counterfactual semantics that make no use of possible worlds. I argue that, as a result of their counterfactual semantics, dispositionalists are in fact committed to entities that play the same theoretical role as possible worlds. Roughly, the claim is that certain counterfactuals (ones that concern 'very large' states) force the dispositionalist to posit world-sized states that play the theoretical role of worlds. As a result, dispositionalists can (and perhaps should) make use of the mainstream framework (Kripke frames and the Lewis–Stalnaker counterfactual semantics) even if they ground all modal facts in dispositions.

Dispositions (powers, potentialities) have become popular in metaphysics in recent years, and some of their proponents are advertising them as the best metaphysical grounds for modality. The rough idea behind the dispositional theory of modality is that $\Diamond P$ is true, whenever it is, because something is disposed to ϕ such that ϕing entails that P. Theories in this vicinity have been pitched as important new alternatives to older analyses of modality that used possible worlds.

Proponents of dispositional modality tend to construct new systems of modal logic that make no mention of possible worlds. The central thesis of the present paper is that despite this predilection, dispositionalists are committed to possible worlds by default, even if they refuse to talk about them. As a result, a version of the mainstream framework—Kripke frames plus Lewis–Stalnaker semantics—is available to friends of dispositions as well. It offers plenty of benefits, more than homegrown dispositionalist logics. Or so I will argue.

After an introduction on dispositions and their connection to the ontology of modality (Sect. 1), I will argue that dispositionalist counterfactual semantics entails

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the existence of things that play the theoretical role of possible worlds (Sects. 2 and 3). The rough idea is that certain counterfactuals (ones that concern 'very large' states) force the dispositionalist to posit world-sized states. I support this claim with both metaphysical and formal arguments. Since dispositionalists are committed to possible worlds anyway, they can, in principle, use them to build a Kripke frame and a version of the Lewis–Stalnaker semantics without further ado. This move brings significant formal benefits without any ontological cost (Sect. 4).

1 Dispositionalist Counterfactual Semantics

Dispositions are properties that make their bearers liable to cause or undergo change. Fragility is a paradigm disposition: if something is fragile, it is liable to break when struck.

Dispositions abound. It is easy to multiply the examples. Indeed, many if not most of the properties that science studies, such as mass and electric charge, are partly if not purely dispositional.

In the last few decades, an exciting and extremely convoluted debate developed about the reducibility of dispositions to conditionals (or, generally, to nondispositional properties). The basic reductionist idea, going back to Carnap (1936) and Ryle (1949/2009: 31), is that ascribing some disposition, for example fragility, to x is tantamount to asserting a conditional like "If x were dropped, then x would break". This project is generally considered to have failed,[1] which led many metaphysicians to treat dispositions (or at least a select few of them) as *sui generis* components of reality. Since dispositions are obviously modal in character, treating them as *sui generis* components of reality leads to a view on which reality is irreducibly modal simply in virtue of the properties of physical particulars. And that, in turn, opens up the way to a new conception of modality that bypasses possible worlds.[2]

Dispositions come in many shapes and sizes nowadays. Some authors prefer to talk about powers (Molnar, 2003) or potentialities (Vetter, 2015) instead of dispositions. Some believe that dispositions have stimulus conditions (Bird, 2007), others think they are individuated by their effects only (Lowe, 2011), and still others claim that we should recognize not just stimuli and manifestations but also dispositional *influences* (Corry, 2019). Some argue that the actualization of a disposition precedes its manifestation (Molnar, 2003), others believe that it is simultaneous with it (Chakravartty, 2007). Some conceive of dispositions as causally potent intrinsic properties (Anjum and Mumford, 2011), while others offer more abundant conceptions on which some dispositions are extrinsic (McKitrick, 2018) or lack causal clout (Nolan, 2015).

What unifies all those conceptions, as far as the present paper is concerned, is the intuition that dispositions (powers, potentialities) point to (are directed at) some state or property that need not be present when the disposition is present. Fragility points to breaking in this sense, and magnetism points to attraction. A glass can

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[1] See McKitrick (2018, ch.2) for an overview.

[2] See Vetter (2015, ch.1) for more on this research program.

be fragile without actually breaking, and things can be magnetic without actually attracting anything. I use "disposition" as a blanket term for properties that point to other properties or states in this sense.

Friends of dispositions disagree about the modal strength of pointing. According to Anjum and Mumford (2018), what I call "pointing" is a primitive modal notion that falls between strict necessity and mere possibility. For Bird (2007), it is a form of conditional necessity, while Vetter (2015) treats it as something very close to mere possibility. When I talk about pointing, I intend to be neutral on its modal strength.

A number of authors seek to explain modality in terms of dispositions. I will call this idea "dispositional modality", or "dispositionalism" for short. Here are two programmatic statements:

> [W]e develop our account of possibility on the understanding that dispositionality is the source of causal potency [...]. We can deal with our modal assertions on the basis of dispositions present in the actual world, so there is no need to postulate a world of propositions, or a vast array of possible worlds (Borghini & Williams, 2008, 24–29).
> I offer a powers semantics for counterfactuals [...]. Together with a definition of possibility and necessity in terms of counterfactuals, the powers semantics of counterfactuals generates a semantics for modality that appeals to causal powers and not possible worlds (Jacobs, 2010, 228).[3]

I will focus on dispositionalist counterfactual semantics, a subproject within this approach, which seeks to find dispositions-based truth conditions for claims like "If A were the case, then B would be the case" ($A \,\square\rightarrow B$). Three proposals are specific enough to merit discussion, Jacobs (2010), Shope (1987), and Vetter (2015, 225–227). Their terminology is different, but their overall shape is similar. Suppose we are in a context where the following is true:

(1) If the key were near the magnet, it would stick to the magnet.

One could suggest that (1) is true because *being magnetic* points to the key's sticking to the magnet, more precisely, (1) is true because the magnet has a disposition that will manifest in the consequent of (1) under conditions specified by the antecedent. This idea can be unpacked by invoking the notion of manifestation chains. Call "a manifestation chain," or simply "a chain" any series of possible states of affairs $S_1, S_2 \ldots$ such that the dispositions in S_{K-1} collectively point to state S_K. There are two basic ways to generate a counterfactual semantics from manifestation chains:

(C1) $A \,\square\rightarrow B$ iff for any manifestation chain $\mathbf{C}$, if $\mathbf{C} \vdash A$, then $\mathbf{C} \vdash B$

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[3] For more details, see Borghini and Williams (2008), Jacobs (2010), Vetter (2015, 103), and Warmke (2016). Bird (2007), Ellis (2001), Molnar (2003), and Mumford (2021, ch.5) support the idea of modal dispositionalism without formally developing it. As Yates (2015) noted, grounding metaphysical *necessity* in dispositions is not wholly unproblematic, but I will bracket this issue here—I assume, for the sake of argument, that necessity can also be located in dispositions somehow (see Vetter, 2018 for a solution).

(C2) $A \,\square\!\rightarrow B$ iff there is no manifestation chain **C** such **C** $\vdash A$ and **C** $\vdash \neg B$

I will come back to the definition of entailment ($\vdash$) presently. Modulo terminological differences and some fine details, Jacobs (2010, 243–245) and Shope (1987) adopt (C1),[4] while Vetter (2015, 225–227) adopts (C2).[5]

The main difference between (C1) and (C2) is that (C2), unlike (C1), leaves it open whether all possible states are part of some chain. By (C1), it is true that $2 + 2$ would have been 4 no matter what (for any P: $P \,\square\!\rightarrow 2 + 2 = 4$) iff $2 + 2$'s being 4 is entailed by every manifestation chain. But if chains are composed of disposition manifestations, then $2 + 2$'s being 4 is not entailed by any chain unless some dispositions manifest in rules of arithmetic, which is a weird idea. This problem does not arise for (C2).

The precise nature of manifestation chains varies from author to author. For Jacobs, manifestation chains are series of (interpreted) sentences. Shope takes them to be series of propositions, while Vetter's preferred posits are iterated potentialities, which are potentialities for having potentialities. For definiteness, I will take manifestation chains to be series of possible states of affairs. If S is a state, then "**C** $\vdash S$" ("**C** entails S") denotes the claim that the proposition "All members of **C** obtain" logically implies that S obtains. To avoid clutter, I will be cavalier about the difference between a state S and the proposition that S obtains.

An interlocutor could (rightfully) complain that my definition of $\vdash$ reifies possibilia and hence it implies that pointing (directedness) is a real relation; specifically, in the case of unmanifested dispositions, it is a relation between a disposition and a merely possible state. However (the interlocutor could continue) dispositionalists typically reject possible states. Those who are 'hardcore actualists' (Contessa, 2010, 341) believe only in states that are actually present—for example, Vetter (2015, 272) thinks that unmanifested manifestations are 'in' the potentialities that point to them, Giannini (2021) develops the concept of mere logical existents, while Jacobs (2010) rejects ontological commitment to unmanifested properties altogether and he treats (actually instantiated) powers as the sole truthmakers of counterfactuals. Merely

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[4] For Shope, $A \,\square\!\rightarrow B$ is true iff there is an admissible set Γ of propositions that describe a manifestation chain so that $\Gamma \vdash A$ and $\Gamma \vdash B$. Admissible sets are generated by this protocol:

(S1)   Let Γ_0 be a set containing A as well as true atomic and negated atomic propositions that are logically compatible with A.

(S2)   Let Γ_1 be the set containing Γ_0 plus some propositions that, in virtue of the dispositions they refer to, describe a sufficient causal base for Γ_0. (If there is no such Γ_1, choose a different Γ_0.)

(S3)   Let Γ_2 be the set containing Γ_1 plus the causal consequences necessitated by Γ_1.

...and so on. $\Gamma = \cup_i \Gamma_i$ is then an admissible set. The Shopian version of (C1) is found on p.398 of Shope (1987). As for its components, "RBP" ("rock-bottom proposition") is defined on p.385, "A*" on p.387, "strongly A*-admissible" on p.388, "linkwise description of a chain" on p.397 (chains themselves on p.392). The function of contrast sets M and M' is explained on p.396.

[5] For Vetter, "If $A(x)$ had been the case, $B(x)$ might have been the case", $A(x) \,\Diamond\!\rightarrow B(x)$, is true iff x has the iterated potentiality for state $B(x)$ such that $A(x)$ is part of the iteration leading to $B(x)$. Iterated potentiality is the ancestral of the relationship that I call "pointing" (Vetter, 2015, 135–139 and 311). From this idea, (C2) can be derived via the formal definition of the 'might' counterfactual: $A \,\Diamond\!\rightarrow B$ iff $\neg(A \,\square\!\rightarrow \neg B)$ (Lewis, 1973, 21).

possible states are avoided even by some friends of dispositions who are not hard-core actualists; for example, Tugby (2013) posits uninstantiated Platonic universals to account for unmanifested manifestations.

I reply that quantification over merely possible states is a convenient *façon de parler* in this paper. I do not mean to beg the question against any specific theory of dispositions. In what follows, existential quantification over states and chains does not feature the 'joint-carving' quantifier of Sider (2011). It is meant to be para-phrased into proper dispositionalist 'Ontologese', but the way to do this will vary from one dispositionalist metaphysic to the next. In Vetter's framework, my claim that that there is a merely possible state of something's being *F* should be expressed as the claim that some (actual) particular is either potentially *F* or potentially such that something is *F* (Vetter, 2015, 272). In Giannini's framework, one will say that some actually instantiated power is directed at a mere logical existent's being *F*; in Jacobs's framework, one will say that some actually instantiated power makes "Whatever were the case, nothing would be *F*" false (Jacobs, 2010, 241). And so on. Since there is no general formula that captures all of these ontologically more perspicuous locutions, I use a metalanguage that makes the logical structure of dispositionalist counterfactual semantics easy to grasp but which is ontologically light-weight in the sense that its existence claims are not meant be taken at face value.

It is important to note that (C1) and (C2) are simplifications: we must not quantify over absolutely all chains, on pain of delivering very counterintuitive results. Suppose that the manifestation chain $\mathbf{C}^*$ entails that my favourite vase is protected by a sorcerer, so that the vase won't break when dropped. This is a remote context—no sorcerer is actually protecting my favourite vase and it would be hard for me to employ one. And so in the context in which I actually find myself, it is true that the vase would break if I dropped it. But given the existence of $\mathbf{C}^*$, (C1) and (C2) deliver the verdict that the vase would not break if I dropped it. To deliver the right truth values, (C1) and (C2) should quantify over a restricted set of chains only, namely those that are relevant in (or 'close to') the context in which the counterfactual is evaluated. The fully precise version of (C1) should say that $A \; \square \rightarrow B$ is true in context *X* iff all chains that are relevant in *X* entail *B* if they entail *A*. Analogously for (C2). Whether a chain is relevant will depend on its overall similarity to the context of evaluation. In the interest of brevity, I omit these technical details, which dispositionalists themselves are reticent about.[6]

2 World-Sized Manifestation Chains

(C1) and (C2) lead to possible worlds. Consider the following counterfactual:

(2)   If Nixon had pushed the button, energy would have been conserved throughout the history of the universe.

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[6] Cf. the condition of **Normalcy** in Jacobs (2010, 243).

This counterfactual is true, since not even the president of the USA can violate the laws of physics. Under (C1), (2) is true iff no chain entails Nixon's pushing the button or some chain entails Nixon's pushing the button and all such chains entail the conservation of energy. The former option can be ruled out.[7] So some chain entails Nixon's pushing the button and all such chains entail the conservation of energy. Let **C** be such a chain. By assumption, **C** entails that energy is always conserved. Since nothing but the whole history of the universe can guarantee that energy is always conserved, **C** is a nonactual series of states that spans a whole alternative history (one in which Nixon pushed the button). **C** contains that nonactual history down to the smallest physical details, from beginning to end, entailing that nothing else is part of it. (Without such richness or without a totality condition, **C** could not entail a conservation law.) But then **C** is suspiciously similar to a possible world. It is a sort of 'maximal' possibility, the full description of a merely possible universe. (C2) leads to world-sized chains for analogous reasons.[8]

One could object that **C** *qua* truthmaker of (2) may be silent on a whole number of issues even if **C** includes every physically significant fact. **C** could be silent on the global distribution of qualia (if qualia are epiphenomenal) or on the existence of moral facts (if the latter are nonphysical). But one can build such antiphysicalist posits into the consequent without affecting the main point. For example:

(2†) If Nixon had pushed the button, then energy would have been conserved throughout the history of the universe and the laws about the distribution of qualia would have been the same, along with all nonphysical moral facts.

Moreover, the point can be made without bringing in laws of any kind.[9] Let *H* be the complete description of a possible history where Nixon pushes the button, and consider the following claim:

(3) ¬(*H* □ →Nixon does not push the button)

This claim is true, since Nixon pushes the button according to *H*. Under both (C1) and (C2), (3) is true iff there is a manifestation chain that entails *H*. But such chains are world-sized.

Counterfactuals like the following work equally well:

(4) If Nixon had pushed the button, the global distribution of chemical elements would have been roughly the same throughout the history of the universe.

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[7] If no chain entails Nixon's pushing the button, then "Nixon pushes the button □ → *P*" is true for any *P* according to both (C1) and (C2), which sounds wrong (e.g. *P* = the Moon turns into cheese).

[8] To run the argument for (C2), let (2*) consist of the antecedent of (2) and the negation of the consequent of (2). Assuming that some chain entails the antecedent of (2), the falsity of (2*) implies the existence of a world-sized chain under (C2).

[9] Thanks to a reviewer for this point.

The truth conditions of (4) entail the existence of a world-sized chain for reasons analogous to the case of (2). Nor is it important that (2)–(4) are noncausal. The existence of world-sized chains will also follow from a causal claim like (5):

(5) If Nixon had pushed the button, he would have made a difference to his forward lightcone without making any difference to the rest of the universe.

What is common to (2)–(5) is that their antecedent or their consequent implies a worldwide totality condition. True counterfactuals whose antecedents and consequents collectively entail some worldwide totality condition (e.g. $P \,\square\!\rightarrow F$, with P a complete possible past and F a complete possible future) lead to the same result.

There is a further route to world-sized chains if one accepts that a state is possible iff it is is entailed by some chain. That biconditional can be established from a commonly hypothesized link between counterfactuals and possibility (to be discussed in Sect. 3):

(6) $\lozenge S$ iff $\neg(S \,\square\!\rightarrow \bot)$

According to both (C1) and (C2), $\neg(S \,\square\!\rightarrow \bot)$ is true iff some chain $\mathbf{C}$ entails S and $\mathbf{C}$ does not entail a contradiction. The latter is true for any $\mathbf{C}$ (except for dialetheist dispositionalists, but that position is thankfully unoccupied in theoretical space). So if (6) is accepted, then S is possible iff S is part of some chain. Now suppose that B and F are the backward and the forward lightcones, respectively, of some possible state S. To simplify, assume determinism, so that S has exactly one possible backward and one possible forward lightcone. In that case, the following counterfactual is true:

(7) $B \,\square\!\rightarrow F$

Call the conjunction of B and F "the full lightcone of S". (7) is true according to (C1) iff every chain that entails B contains the full lightcone of S. Since B is possible, (6) guarantees that some chain entails B, and so some chain contains the full lightcone of S. Let S be the current time-slice of the universe (from some fixed inertial frame), and let the chain $\mathbf{C}$ contain the full lightcone of S. $\mathbf{C}$ is then a world-sized chain—in fact, it represents the actual world in its entirety. Nonactual worlds arise if S is a merely possible time-slice.

One can derive the same result under (C2). Since $\neg(B \,\square\!\rightarrow \neg F)$ is true, there is, by (C2), a chain $\mathbf{C}$ such that $\mathbf{C} \vdash B$ and $\mathbf{C} \vdash F$. If S is the current time-slice of the universe, then $\mathbf{C}$ is a world-sized chain.

The argument is easy to extend to indeterministic laws and alien laws. In indeterministic regimes, one can use the 'might' counterfactual $B \,\lozenge\!\rightarrow F$, defined as $\neg(B \,\square\!\rightarrow \neg F)$, instead of (7). For alien laws, lightcones can be replaced with the relevant analogue in the nomic regime at hand (determined by the speed of causal influence).

It might be objected that world-sized chains do not fit any of the standard metaphysical conceptions of possible worlds: they are not maximal consistent sets of propositions, parallel universes etc.

I reply that for any way that one can conceive of chains, there is a mainstream conception of possible worlds that portrays world-sized chains, or some object constructible from them, as worlds. For example, if chains are series of propositions, then the logical closure of the set of propositions that constitute a world-sized chain will be a maximal set of compossible propositions, and hence a world in the sense of Adams (1974). If chains are series of complex properties, then the fusion of all members of a world-sized chain is a complex property that characterizes a whole universe, and so it is a world in the sense of van Inwagen (2001, 169–171). If chains are series of states and states are immanent facts or recombinations thereof, then world-sized chains are worlds in the sense of Armstrong (1989). And so on.

One could resist my argument by rejecting the whole idea of 'chain-based' semantics. Perhaps the dispositionalist needs wholly different foundations for her theory of counterfactuals.

I can't refute this suggestion. But variants of (C1) and (C2) *are* the only proposals on the table right now, so my argument applies to the state of the art in this area. If dispositionalists think they have better alternatives in counterfactual semantics, the burden of proof is on them.

One could question my tacit presupposition that the dispositionalist *needs* a counterfactual semantics. Perhaps that's false. Grounding possibility and necessity in dispositions might be perfectly enough.[10]

Against this objection, I would point out that dispositionalists routinely allege that dispositions explain counterfactuals, so this response contradicts widespread assumptions in the field.[11] Moreover, trying to explain metaphysical possibility without explaining counterfactual truth leads to an abductively inferior modal metaphysic, or so one can argue. Counterfactuals play crucial roles in most areas of philosophy: they are central to thought experiments, they drive highly influential analyses of causation, lawhood, knowledge, moral responsibility, and so on. If the dispositionalist cannot explain how counterfactuals come to have truth values, then dispositionalism may very well be preferable to alternative theories of modality that have more explanatory power.

Instead of denying that world-sized chains are *de facto* possible worlds, the dispositionalist could deny that world-sized chains *exist*. Perhaps they are mere logical fictions, not to be imported into one's ontology, and the question of their similarity to possible worlds is therefore a non-issue.

This suggestion is problematic because of the basic shape of the dispositionalist semantics. If world-sized chains do not exist, how can they enter the truth conditions of counterfactuals? Note, further, that dispositionalists' views about the ontology of unmanifested manifestations (a category that covers world-sized chains) typically do

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[10] This might be the case, for example, if most counterfactuals are false. For a defense of such a view, see Edgington (2004); against, see Bennett (2003, 252–256).

[11] See Bird (2007, 60), Borghini and Williams (2008, 24), Cartwright (1989, 142), Hüttemann (2013, 114), Jacobs (2010), Shope (1987), Vetter (2015, 225ff).

not entail that the latter don't exist. On Vetter's broadly Aristotelian view (2015, 272), uninstantiated properties do exist, although they depend on instantiated potentialities. Giannini (2021) is ontologically committed to mere logical existents (which are, if I understand correctly, contingently abstract particulars), Tugby (2013) posits Platonic universals, and Mumford (2004: 180) posits uninstantiated properties. Theories in this camp all lead to the conclusion that world-sized chains exist.

Of the authors mentioned at the end of Sect. 1, only Jacobs avoids a commitment to unmanifested dispositions: he claims that powers make counterfactuals about unmanifested manifestations true all by themselves, without unmanifested manifestations entering the ontology (Jacobs, 2010, 236). This is a metaphysically primitive phenomenon in the sense that powers do not have any internal structure that explains why they make certain counterfactuals true; they just do. Since this approach makes absolutely no commitment to unmanifested manifestations, it may seem to undercut my claim that dispositionalists must posit worlds.[12]

In response, one can restrict my argument to those dispositionalists who are realists about unmanifested manifestations. This strategy can be complemented with a criticism of Jacobs-style semantics.[13] But it seems to me that there is a more straightforward response: Jacobs, despite his refusal to acknowledge unmanifested manifestations, *is* committed to abstract objects that can play the role of worlds. In his counterfactual semantics, manifestation chains are infinite sequences of consistent sets of formulas, with each member of such a sequence being "a power to bring about the next stage" (Jacobs, 2010, 243–244). This semantics is obviously committed to the existence of sentences, and to sets of sentences. More precisely, it is committed to *interpreted* sentences—otherwise sets of formulas would be heaps of empty symbols and they could not be identified with powers. Further, many of the sentences in question must be about unmanifested dispositions, otherwise the semantics will be unable to handle counterfactuals with a false antecedent. Since Jacobs is committed to sets of sentences about unmanifested dispositions, his view leads (if the rest of my foregoing argument is correct) to abstract possible worlds in the form of maximal compossible sets of sentences.[14]

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[12] Heil (2003, 222), Martin and Pfeifer (1986), and Molnar (2003, ch.3) may also be sympathetic to this approach, since they all buy into the idea of 'physical intentionality', which, just like mental intentionality, is supposed to be characterized by the nonexistence of the intentional object. Thanks to a referee for drawing my attention to these approaches to unmanifested manifestations.

[13] For example, one can argue that Jacobs cannot explain why a given power makes a counterfactual true. Alternatively, one can argue that the view in question cannot make sense of the reference of singular terms within counterfactuals (Giannini, 2021, 2690).

[14] A set Σ of sentences is compossible iff there is a chain **C** such that every member of Σ is true in **C**, and Σ is maximal iff Σ entails every sentence that is true in some world-sized chain (For the definition of truth in a chain, see Jacobs, 2010, 245).

The Jacobsian can perhaps reply that the resulting 'worlds' (maximal compossible sets of sentences) will be language-dependent and hence a far cry from the mind-independent structures of classic modal abstractionism. But one can easily generate language-independent surrogates for the latter by identifying worlds with equivalence classes of maximal compossible sets of sentences. (Set S_1 of sentences of language $\mathscr{L}_1$ will be equivalent, in the relevant sense, to set S_2 of sentences of language $\mathscr{L}_2$ iff S_2 is the translation of S_1 from $\mathscr{L}_1$ to $\mathscr{L}_2$).

In the rest of the paper, I pursue two goals. First, I will argue that world-sized chains play the same logical role as the possible worlds of standard modal logic (Sect. 3). I will then argue that world-sized chains can be used to build a version of mainstream modal and counterfactual semantics without undermining the metaphysical ambitions of dispositionalism (Sect. 4).

3 World-Sized Chains Play the Logical Role of Worlds

World-sized chains play the same theoretical role in dispositionalist modal logic as possible worlds do in mainstream modal logic. In mainstream modal logic, possibility is equivalent to truth in some possible world and necessity is equivalent to truth in all possible worlds: $\Diamond P$ is true iff there is a possible world where P, and $\Box P$ is true iff there is no possible worlds where $\neg P$. (More precisely, this is the case in S5. I'll come back to this.) The goal of the present section is to prove that analogous biconditionals are satisfied by world-sized chains.

Specifically, my goal is to prove the dispositionalist analogue of the following principle:

(PW) $\Diamond P$ iff there is a possible world where P

Strictly speaking, (PW) should index truth to worlds and it should mention accessibility ("$\Diamond P$ is true at world w iff P is true at a world accessible from w"). I will discuss this complication later.

The dispositionalist analogue of (PW) is the following biconditional:

(DPW) $\Diamond P$ iff some world-sized chain entails P

This principle can be derived from three axioms (I–III) and a lemma (IV):

- (I) $\Diamond P$ iff $\neg(P \Box \to \bot)$
- (II) Deduction within conditionals: If $A \Box \to B_1$ and $A \Box \to B_2$ and C is a logical consequence of $B_1 \wedge B_2$, then $A \Box \to C$.[15]
- (III) Chains are logically coherent: For any manifestation chain $\mathbf{C}$ and state S, if $\mathbf{C} \vdash S$, then it is not the case that $\mathbf{C} \vdash \neg S$.
- (IV) If $\Diamond P$, then for any Q, either $P \Diamond \to Q$ or $P \Diamond \to \neg Q$.[16]

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[15] For the general version of this axiom schema, see Lewis (1973: 132).

[16] $P \Diamond \to Q$ ("If P were the case, Q might be the case") is defined as $\neg(P \Box \to \neg Q)$ (1973, 21). (IV) is the principle of excluded middle for 'might' counterfactuals. (Excluded middle for 'would' counterfactuals is a different principle that is unlikely to be an axiom, see Lewis, 1973, 79–82.) To prove (IV), suppose that $\neg(P \Diamond \to Q)$ and also $\neg(P \Diamond \to \neg Q)$. By the definition of $\Diamond \to$, it follows that $P \Box \to Q$ and $P \Box \to \neg Q$. By (II), it follows that $P \Box \to \bot$, and by (I), $\neg \Diamond P$. So the modus tollens version of (IV) follows from (I) and (II).

Left-to-right direction of (DPW): Let E be the proposition that energy is conserved throughout the history of the universe,[17] and let S be some possible state. By (IV), either $S \diamond \rightarrow E$ or $S \diamond \rightarrow \neg E$. Suppose that $S \diamond \rightarrow E$, and hence (by the definition of $\diamond \rightarrow$), $\neg(S \square \rightarrow \neg E)$. Under both (C1) and (C2), it follows that some chain entails $S \wedge E$. For reasons discussed in Sect. 2, every such chain is world-sized, therefore some world-sized chain entails S. Analogously, if $S \diamond \rightarrow \neg E$, then some world-sized chain entails $S \wedge \neg E$. So whenever something is possible, there is a world-sized chain that entails it.

Right-to-left direction of (DPW): Suppose that some world-sized chain **W** entails P and suppose that $P \square \rightarrow \perp$. Under both (C1) and (C2), it follows from (III) and $P \square \rightarrow \perp$ that no chain entails P. This contradicts our presupposition, so $P \square \rightarrow \perp$ is false and hence $\diamond P$ is true because of (I).

As I mentioned, (PW) presupposes that accessibility is an equivalence relation. This is a widespread assumption in contemporary metaphysics.[18] Still, it is legitimate to ask what happens to (DPW) if the logic of metaphysical modality is weaker than S5, so that (PW) must be replaced by this principle:

(PW*) $\diamond P$ is true at world w iff P is true at some world accessible from w

Since (DPW) does not mirror (PW*), an interlocutor might worry that world-sized chains will not play the same role as possible worlds if the logic of metaphysical modality is weaker than S5. This issue is especially important because some dispositionalists think that their modal systems are weaker than S5.[19]

If the dispositionalist is committed to a modal logic weaker than S5, then her simplest strategy is to claim that that (I)–(IV) in fact lead to the following weaker principle:

(DPW*) $\diamond P$ iff some accessible world-sized chain entails P

This principle is justified if the dispositionalists builds accessibility into her counterfactual semantics, so that only chains that are accessible from the context of

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[17] For antiphysicalists, let E be the consequent of (2†) or something similar.

[18] See Hale (2020, 141) and Williamson (2013, 110–115) for arguments for S5 based on the idea that metaphysical possibility and necessity are non-contingent. For challenges to S5, see Dummett (1993, 346) (replies: Reimer, 1997; Rumfitt, 2010), Salmon (1981, 238–240) (also Salmon, 1989; Salmon, 1993; replies: Williamson, 1990; Williamson, 2000), Stephanou (2000) (reply: Gregory, 2001), Hayaki (2005, 32–35), and Wedgwood (2007, 215–220). For dispositionalist challenges to S5, see the next footnote.

[19] Vetter (2015, 196, 212–213) argued that the logic of potentiality may not validate either the S4 axiom or the S5 axiom and it may be as weak as T. (In the lingo of Kripke frames, T is the system where accessibility is reflexive, so that $A \rightarrow \diamond A$ is an axiom.) Vetter's official semantics validates the S4 but not the S5 axiom (Vetter, 2015, 314). Kimpton-Nye (2021) advocates for S5 within the same context. Warmke (2016) tentatively argues that Jacobs's semantics leads to a version of S4.

evaluation feature in the truth conditions of counterfactuals. In that case, (DPW*) is provable the same way as (DPW).[20]

I can see two ways to build accessibility into the dispositionalist counterfactual semantics. First, one can appeal to the notion of being possible relative to some context, and one can identify it with accessibility while also claiming that the quantifiers in (C1) and (C2) must be restricted to chains that are possible relative to the context of evaluation. Among other things, this will entail that P is impossible relative to context X iff $P \,\square\!\!\rightarrow\, \bot$ is true in X,[21] so the dispositionalist can derive a version of (I) from first principles. She can also prove (DPW*).[22] Since some metaphysicians do identify accessibility with relative possibility (e.g. Dummett, 1993: 345), this approach is not unmotivated. Of course, dispositionalists cannot take relative possibility to be primitive; they must find some dispositional ground for it. For example, they can say that P is possible in context X iff there is a chain $\mathbf{C}$ such that $\mathbf{C} \vdash X \wedge P$.

Alternatively, one can establish (DPW*) by formally connecting counterfactual similarity to accessibility. To illustrate, let me use the mainstream framework (= Kripke frames for the box/diamond and the Lewis–Stalnaker semantics for counterfactuals). In that framework, accepting (I) allows one to identify accessibility with a form of counterfactual similarity: roughly, it will follow from (I) that world u is accessible from w iff u is one of the closest P-worlds, relative to w, for some proposition P (Kodaj, 2016). Once a counterfactual similarity relation fixes the relative closeness relations between worlds, accessibility is also fixed. If the dispositionalist finds a similar formal link between counterfactual similarity and accessibility, she can prove (DPW*).[23]

Instead of trying to secure (DPW*), a dispositionalist who is committed to some system weaker than S5 can choose to reject (I) instead. Although (I) is plausible (Lewis, 1973; Williamson, 2010), the dispositionalist may argue that it should be replaced with the following weaker principle ("$\lozenge^n$" denotes n consecutive diamonds):

(I*) $\neg(P \,\square\!\!\rightarrow\, \bot)$ iff for some $n > 0, \lozenge^n P$

According to (I*), counterfactual non-vacuity coincides with the transitive closure of possibility, not with possibility simpliciter.[24] This alternative principle does not allow us to derive (DPW); rather, it will lead to the following thesis:

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[20] Left-to-right direction of (DPW*): Same as the left-to-right direction of (DPW) except that the chain that entails $S \wedge E$ or $S \wedge \neg E$ is accessible because of the modification to (C1) and (C2) mentioned in the main text. Right-to-left direction of (DPW*): Same as the left-to-right direction of (DPW) except that one supposes from the start that **W** is accessible.

[21] If one restricts the quantifiers in (C1) and (C2) to chains that are possible relative to the context of evaluation, then, assuming the logical coherence of chains (III), $P \,\square\!\!\rightarrow\, \bot$ is true in context X iff no chain that is possible relative to X entails P. Since every possibility is part of some chain for dispositionalists, this is tantamount to saying that $P \,\square\!\!\rightarrow\, \bot$ is true in X iff P is impossible relative to X.

[22] Cf. fn. 20.

[23] See Sect. 2.2 of Kodaj (2016) for a proof that can be adapted by the dispositionalist to her own semantics.

[24] For more on the transitive closure of possibility, see Blackburn et al. (2001, 371).

(DPW**) $\Diamond^n P$ iff some world-sized chain entails P

This can be derived from (I*), (II), (III), and the appropriately modified version of (IV) by replacing "$\Diamond$" with "$\Diamond^n$" throughout the proof of (DPW).

(DPW**) does not conflict with systems weaker than S5.[25] Moreover, (I*), which leads to (DPW**), has independent appeal in the context of systems weaker than S5. To illustrate, suppose that the logic of metaphysical modality does not validate the S4 axiom ($\Diamond\Diamond P \rightarrow \Diamond P$) and philosophical zombies are impossible but possibly possible (relative to the actual world). Under (I), it follows that if zombies existed, some logical contradiction would be true, which sounds a bit harsh. If zombies are part of what is possibly possible, then one reasonably expects to find non-vacuous counterfactuals about them. So (I*) seems justifiable if the logic of metaphysics is weaker than S5, and (DPW**) is sufficient proof, in that case, that world-sized chains play the logical role of possible worlds.[26]

4 The Benefits of Going Mainstream

I would like to conclude the paper with some methodological remarks. Specifically, I will argue that there are good abductive reasons in favour of the mainstream (world-based) semantics even if one grounds modality in dispositions. This methodological point is not an original contribution of mine: Lorenzo Azzano (2022) has stressed that dispositionalists can reap the formal benefits of the standard framework by positing worlds. The present dialectic is, however, somewhat different. Azzano appeals to dispositions possessed by the universe as a whole and he identifies merely possible worlds with unmanifested manifestations of those dispositions.[27] In contrast, my thesis is that dispositionalists are committed to worlds because of their counterfactual semantics, regardless of their stance on dispositions possessed by the universe as a whole. (It is perfectly compatible with my foregoing claims that such weird dispositions don't exist.) The intended moral of the present paper is that the dispositionalist ontology by default contains entities that play the roles required to support a standard world-based semantics for counterfactuals and modal operators.

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[25] (DPW**) requires that every world be reachable from every world in a finite number of steps. In the context of dispositionalism, this can be justified by assuming that possibilities form a treelike structure, with alternative histories branching off from a common past (cf. Vetter, 2015, 273–277 and Kimpton-Nye, 2021, 354–357).

[26] Some philosophers (e.g. Brogaard & Salerno, 2013; Berto & Jago, 2019) deny (I) on the grounds that it renders all counterpossibles (counterfactuals with impossible antecedents) true, even though some of them are (allegedly) false. (For pushback, see Lewis, 1973, 24–26; Williamson, 2010, 81–83; Williamson, 2010, 93–96.) Presumably, those philosophers would also reject (I*). This issue is orthogonal to the present dialectic, however, because dispositionalists are typically interested in metaphysical possibility (cf. Vetter, 2016). Unless one believes in necessarily unmanifested dispositions, one can disregard counterpossibles for the purposes of this paper. Necessarily unmanifested dispositions are rarely posited; the only examples I know are Zagzebski (1990), Wierenga (1998), and Jenkins and Nolan (2012).

[27] This idea originates in Bigelow et al. (1992), who claimed that conservation laws are dispositions of the universe as a whole. The idea is further developed in Vetter (2015, 255).

The question is whether dispositionalists hide these entities in the attic or put them to good logical use.

Accordingly, I would like to reiterate some of the points that Azzano makes, this time with a focus on world-sized manifestation chains. I will put forward three claims. The first is that dispositionalists *can* use the mainstream semantics (Kripke frames plus Lewis–Stalnaker). My second claim is that dispositionalists *arguably should* adopt the mainstream framework, because the latter is much better understood formally. My final claim is that *it would be good* if dispositionalists adopted the mainstream framework, because they would thereby solve a lingering mystery about its ontology.

4.1 Can

Dispositionalists *can* go mainstream in modal and counterfactual logic. Kripke frames and Lewis–Stalnaker models have three main components: a set of possible worlds, an accessibility relation, and a closeness relation. The set of worlds can be the set of world-sized chains. Adding a closeness relation is not too hard, because the dispositionalist can repurpose some mainstream definition of closeness (like Lewis, 1986, 47–48). As we saw in Sect. 3, accessibility can be derived from closeness, so adding an accessibility relation incurs no further costs. Of course, the resulting Lewis–Stalnaker model will complement, rather than replace, the home-grown dispositionalist semantics built on (C1) or (C2), since that's where worlds originally come from. Using the Lewis–Stalnaker semantics alongside the home-grown one can nonetheless be justified by the formal sophistication of the former.

An interlocutor could complain that the mainstream framework is ill-suited for dispositionalist purposes, because its core components do not map onto the dispositionalist's fundamental ontology. The dispositionalist's fundamental posits are dispositions and their 'pointing' relations, while the mainstream framework posits worlds with accessibility and closeness relations.

However, there is no reason to think that one's modal semantics must map onto one's fundamental ontology the way the interlocutor suggests. If the dispositionalist can tell a coherent story about the dispositional provenance of world-sized chains and their accessibility and closeness relations, then she is free to deploy them in her modal and counterfactual semantics. If the resulting formal system is simple and powerful, she made a good deal. It is not the job of modal semantics to tell a story about what is fundamental. At any rate, dispositionalism does not seem to entail such a principle.

Further, as Sects. 2 and 3 argued, the dispositionalist must posit worlds anyway. Dispositionalist counterfactual semantics entails the existence of things that play the theoretical role of worlds and that correspond to mainstream conceptions of possible worlds as abstract entities. And so the dispositionalist *can* use the mainstream framework, if she wants. Once she explains the nature and provenance of world-sized manifestation chains (which is incumbent on her anyway), building a Kripke frame and a Lewis–Stalnaker model is formally easy and ontologically pretty much free.

The interlocutor could worry that the dispositionalists' world-sized chains cannot cover all the possibilities that one expects to find in modal metaphysics. Consider the classic question of whether Lewis could have been a poached egg. Intuitively, this is not settled by reference to the unmanifested dispositions of actual physical particulars, because it concerns remote, nomically impossible scenarios. So one has reason to suspect that the dispositionalist can supply a restricted set of worlds only—in essence, she provides a set of alternative histories for the actual world.[28]

This is an extremely important issue. It is, however, orthogonal to the present dialectic, in my view. If dispositions cannot ground remote possibilities *and* there are remote possibilities, then modal dispositionalism is in trouble quite independently of anything I have said. My point is that dispositionalism leads to a commitment to worlds, and so *if* dispositionalism is a good theory of modality, then its proponents can switch to mainstream modal semantics.

Whether dispositionalism *is* a good theory of modality is a difficult issue that I can't hope to settle here. There seem to be three basic responses to the objection at hand. First, the dispositionalist can adopt the "Spoils to the victor" strategy, denying the existence of remote possibilities. If no (actually instantiated) disposition points to *P*, then *P* is metaphysically impossible.[29]

Alternatively, the dispositionalist can claim that remote possibilities are grounded in divine powers, since God surely has the power to bring about any metaphysical possibility.[30] This approach has been worked out in quite a bit of detail (Leftow, 2012; Pruss, 2011). It is probably unattractive to most philosophers, but it constitutes a coherent reply to the interlocutor's worry.[31]

Third, the dispositionalist can go Platonist, identifying remote possibilities with (potential manifestations of) uninstantiated dispositions. This approach is logically coherent but it seems unpopular. One reason for its lack of popularity may be that the existence of uninstantiated properties is a modally loaded fact that is not grounded in dispositions.[32]

4.2 Arguably Should

Arguably, dispositionalists *should* go mainstream or, at the very least, they should treat the mainstream framework as a legitimate option for members of their tribe.

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[28] Thanks to a reviewer for this point.

[29] For examples of this strategy, see Vetter (2015, 272–273) (against alien properties), Vetter (2015, 281–282) (against nomically impossible scenarios), and Vetter (2015, 276–277) (against the possibility of different initial states of the universe).

[30] More precisely, for any possibility *P*, God can weakly actualize *P* in the sense of Plantinga (1974, 173).

[31] Cameron (2008, 272–276) uses an Euthyphro-style dilemma to criticise this approach. Jacobs (2010, 238) replies.

[32] Platonism seems to have few dispositionalist proponents besides Alvarado (2020), Bird (2006), and Tugby (2013). (Thanks to a referee for two of these references.) Note, however, that even if it turned out that a commitment to dispositions goes best with Platonism, it does not follow that reducing modality to dispositions goes best with Platonism. Platonism can provide a theory of modality on its own, without bringing in dispositions (Jubien, 2016).

Dispositionalist modal and counterfactual logic is very much a work in progress, and its formal profile is not very well understood. Consider the following questions:

(Q1) Is this a theorem?
$$(A \,\Box\!\!\rightarrow \neg B) \lor (((A \land B) \,\Box\!\!\rightarrow C) \equiv (A \,\Box\!\!\rightarrow (B \supset C)))$$
(Q2) Is propositional modal logic (PML) complete?
(Q3) Is theoremhood decidable in PML?
(Q4) Is quantified modal logic (QML) complete?
(Q5) Is theoremhood decidable in QML?
(Q6) Is propositional counterfactual logic (PCL) complete?
(Q7) Is theoremhood decidable in PCL?

These (and similar) questions are important. In the mainstream framework, their answers are well known. Not so in home-grown dispositionalist systems, where such topics are rarely if ever addressed.

The same applies to substantive issues like counterfactual closeness. At the end of Sect. 1, I indicated that the dispositionalist must restrict (C1) and (C2) to close (accessible) chains, and the same issue came up in Sect. 3. There is a rich literature on counterfactual closeness in the mainstream framework, but none (as far as I'm aware) on the analogous dispositionalist notion.[33]

I concede, however, that the Lewis–Stalnaker framework is certainly not the only option here: dispositionalists might be able to put truthmaker semantics (Fine, 2012) or situation semantics (Kratzer, 2012, ch.3; Turner, 1981) to equally good use. Those approaches may even fit the spirit of dispositionalism better, since they define counterfactual truth on smaller situations (fragments of possible worlds, as it were), which harmonizes with the idea that dispositional modality is 'local' (Vetter, 2015, 2).[34] I do not mean to suggest that Kripke frames and Lewis–Stalnaker models are inevitable. Still, they are quite strong contenders, given their widespread use and formal sophistication.

4.3 Would Be Good

Dispositionalists not only can, and arguably should, go mainstream in logic; it would be *good* if they did. It would be a welcome development in the metaphysics of modality; specifically, it would solve a lingering mystery about the nature and provenance of possible worlds. The prevailing sentiment is that possible worlds are abstract objects of some sort, but there is no received view about their nature or origin, even though heroes of the old orthodoxy are on record claiming that worlds are not fundamental. For example, Kripke wrote:

> I do not think of "possible worlds" as providing a reductive analysis in any philosophically significant sense, that is, as uncovering the ultimate nature,

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[33] Jacobs (2010, 243) mentions close chains in his **Normalcy** condition, but he does not develop this concept any further.

[34] Thanks to a reviewer for this point.

from either an epistemological or a metaphysical point of view, of modal operators, propositions, etc., or as "explicating" them. (Kripke, 1980, 19n18)

Apparently, Plantinga agrees with this point: Pruss (2011, 284n) reports that he thinks of worlds as thoughts in God's mind, which implies that the existence and nature of worlds are explained by more basic facts.

Dispositionalists can justify such sentiments by deriving worlds from dispositions. Very roughly, the claim would be that possible worlds exist because dispositions exist; possible worlds are patterns of manifestations that could arise from the global interplay of powers. Possible worlds are not free-floating abstracta that mysteriously encapsulate everything that might have been the case; their ontology is the ontology of unmanifested manifestations. It seems to me that such insights would advance the debate about the substantive content of the mainstream framework.

Declarations

Conflict of interest The author declares that they have no conflict of interest.

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